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THE NEW NILE RESERVOIR.

BY FREDERIC COURTLAND PENFIELD, FORMERLY UNITED STATES DIPLOMATIC AGENT TO EGYPT, AND AUTHOR OF "PRESENT-DAY EGYPT."

"The triumph of practical science, such as irrigation, bearing no relation to the sword or diplomacy, which turns a single acre of desert sand into a productive field, must be a thousandfold more valuable to the world than the victory of arms that merely changes a frontier or deprives a defeated nation of a single foot of soil: it is the victory of peace; it is creation."—*Present-Day Egypt.*

THE African continent has coincidentally been the theatre, during the past four years, of two gigantic enterprises, both of British origin, backed by British credit, and aimed professedly at improvement in the condition of humanity. In one of them the resources of military genius and preponderating strength brought two interior South-African republics under monarchical rule; while the other project, worked out at the first cataract of the Nile by a handful of resourceful engineers, has permanently extended the area of cultivable Egypt by nearly twenty per cent., and great belts of the desert, contiguous to the Nile, will hereafter be forced to surrender their aridity to the production of standard crops that feed mankind.

The military achievement cost an appalling sum in life and treasure; the object lesson in practical expansion a comparatively insignificant amount, to be recouped in a few years by nature's bounty. To my mind, the triumph of the studious engineer is thousands of times greater than that of Field-Marshal and General; but the meed of official praise is given overwhelmingly to the men who wrought with the sword.

In the western world we may have an insufficient understanding of the physical conditions which explain the importance of the great dam at Assouan, dedicated by the Egyptian Khedive on the 10th of last December.

Egypt being practically rainless, the Nile is perforce the sole medium of fertility; and this river, created by torrential rains in Abyssinia and the overflow of equatorial lakes, and without affluent in Egyptian territory, has a volume which varies with the seasons. For four months the flood rushing seaward is known as High Nile; it inundates hundreds of miles of valley and Delta, enriching the soil in preparation for seeding. Then come eight months of Low Nile, which, were it not for man's forethought, would result in parched fields, and the productive capacity of the country would be reduced to an extent meaning famine. The husbanding of the surplus water of the flood season, and its systematic liberation during the burning summer months, secure prosperity; for, wherever the fertilizing water can be directed, the desert sands are deprived of their aridity, and blossom into vegetation rich enough to tax credulity.

As a vocation, the pursuit of agriculture in Egypt is fraught with conditions that may well appear strange to the farmer in America or Europe, where water falls providentially from the clouds. Along the Nile, water must be lifted from the river or canals, every drop of it, and ingeniously inducted to every foot of soil under crops; none comes by gravitation. The elevation varies from fifteen to twenty-five feet, and is accomplished mainly by manual labor operating shadoofs—really the primitive pole-and-bucket system. Those who farm in a biggish way, comprehending industrial economies, employ animal-driven chains of buckets; and landed proprietors of financial resources employ steam-pumps to irrigate their fields. Ten or fifteen years ago, practically all irrigation was effected by manual or animal labor.

As soon as his crops are sown, the Egyptian becomes an irrigationist for a period of nearly a hundred days. If unprogressive enough to retain his shadoofs, he has to figure on a workman for each acre under summer crops; and, to saturate this acre once, the fellah must raise nearly four hundred tons of water; and this same acre must be fertilized in that way four or five times in a season. The labor required for irrigating is computed at $10 per acre. The sakieh-farmer, using chains of buckets, accomplishes it for less; the capitalist owning modern pumps for half as much. It is a conservative statement that one-half the male population of Egypt, in summer, is employed in water-hoisting. But the shadoof is doomed: it is being crowded out by labor-saving inventions.

The Egyptian husbandman has some advantages over his brethren in other climes, however. He never heard of frost, and he encounters neither trust nor labor organization. He may not know what the price of grain, cane, or cotton will be at a future date; but he can compute to a nicety what his crop will measure, and what it will cost him. He gathers two crops a year from the same piece of land, and sometimes three. If his sons and relatives are insufficient for his requirements, for from two to three piastres (ten to fifteen cents) a day he can employ a steady, reliable laborer, willing to wait for his wages until the crop is marketed.

The desert is illimitable, and the water supply can be made almost inexhaustible. Consequently, the irrigation engineer in Egypt has long had before him definite factors, which, if practically conjoined, meant certain and golden results. The old barrage near Cairo, made in Mehemet Ali's time by French engineers, and reconstructed under the British régime later, saved the country from bankruptcy by developing a cotton crop worth fifty million dollars a year; and minor upstream storage basins brought into being crops of sugar and cereals greatly in excess of the Egyptians' wants. It is estimated that the Cairo barrage (at the apex of the Delta) has drawn ten million dollars annually into the national treasury in land taxes for close upon a generation.

The British administration of the Land of the Pharaohs being a business proposition, it had no hesitation in committing to its engineers the task of providing facilities for storing Nile water on a stupendous scale, compelling the great river to pay tribute to agriculture rather than to waste its virtue in the Mediterranean Sea, knowing that the pregnant soil could in a few years be made to defray the cost of any reservoir that man could construct.

The engineers had considerations of every sort to weigh—professional, natural, fiscal—before determining the site for the great reservoir. They came to the conclusion that Assouan, with its bed of syenite granite—the identical lode that furnished the obelisks—beneath the river, and with the favorable conformation of the surrounding country, offered advantages equalled by no other location. Nature had there been lavish in providing hills of solid rock on either bank that will stand the ravages of the elements as long as the world lasts.

A situation thirty miles south of Assouan, at Kalabsheh, was discussed; but there the massive dam would have to rest on a foundation of crumbly sandstone. The Silsila Gate site, fifty miles north of Assouan, was rejected for the same reason, and incidentally because the recently-excavated ruins of Kom-Ombos temple would be destroyed. The re-discovery by an American scholar, Mr. Cope Whitehouse, of the desert depression sixty odd miles southwest of Cairo, known in Bible times as Lake Moeris, was likewise not availed of.

It has long been my opinion that Mr. Whitehouse's project, used in conjunction with the Bahr Youssef canal, had much to commend it; but the law of gravity would confine its sphere of usefulness to the Fayoum province and to the Delta—the latter being already, in all probability, the richest soil on the face of the earth. Mr. Whitehouse claims legal rights in his discovery. When the augmented Egypt shall have "caught up" with the new conditions which must result from the Assouan reservoir, it may naturally be expected that the officials of the Department of Public Works will cast about for storage places between Assiout and Cairo. The possibility of utilizing the Whitehouse plan may then be considered, for perennial irrigation on a large scale is part of the obvious programme of those who control Egyptian affairs.

Probably, the cardinal recommendation of the Assouan site was, that its location on the natural and political frontier, where Egypt joins Nubia, admitted of the fertilizing of the entire length of the Nile valley in Egypt, approximately seven hundred miles.

It may be prophesied that the Assouan reservoir is but one of a series which will in time be constructed southward to Berber, Khartoum, and possibly the Victoria Nyanza itself; the re-establishment of Egyptian authority at Khartoum makes this possible. If so, the Soudan provinces may become important grain producers. But the population of the Soudan must first be recruited and schooled in the handling of labor-saving implements.

As a daring readjustment of nature's surface, the building of the Assouan dam, imprisoning in Nubia a body of water perhaps a hundred and forty miles long, crossing the Tropic of Cancer, and reaching southward nearly to Korosko, was a project outranking anything hitherto attempted by engineering skill; and, as a building scheme, it would have been worthy of a Rameses.

Pyramids and temples have borne testimony, through unnumbered centuries, to the power of execution which formerly dwelt in the valley of the Nile. But the rearing of the Assouan dam,—since it is to minister to the world's necessities, rather than to man's vanity,—is a greater work than the erection of all the Pyramids at Ghizeh. To create a lake having possibly three times the superficial area of Lake Geneva in Switzerland, and to provide the means of controlling it with scientific precision, so that the harnessed flood might be turned into distant channels at will, was a comprehensive undertaking. But the representatives of the Department of Public Works claim that their plans have been carried out to the letter. They computed the water that would be held in bondage, and estimated the resistance which would have to be provided at every point of the masonry. In Cairo, the mathematicians of the Ministry of Finance claim to know the sum that should come into the public treasury from taxation through the country's augmented productiveness.

At Assouan, the Nile is 330 feet above the level of the Mediterranean. From Assouan north to Cairo, the fall is a trifle under five inches in the mile, and from Cairo to the sea about an inch to the mile. It has been computed that at present more than half of the Nile, with its precious sediment from Abyssinia, pours into the Mediterranean—in other words, water and soil enough to create many Egypts are permitted to run to waste.

The Assouan dam was practically the suggestion of Mr. W. Willcocks, the modest but hard-working Director-General of Egyptian Reservoirs, who has been rewarded with British knighthood, although the natural adaptability of the location had for fifty years been discussed by other engineers. When the Cairo administration found itself prepared to begin operations, Sir Benjamin Baker, conspicuous in British engineering undertakings, especially the Manchester canal, was invited to become chief-engineer of the Assouan project, to work in concert with Sir William Garstin, Under-Secretary of Public Works.

The chief-engineer went further than the study of plans and figures in Cairo, for he found a group of London capitalists, headed by Sir Ernest Cassel, willing to finance the scheme from inception to completion, the Egyptian government not being called upon to pay anything until the dam was completed.

Sir John Aird, M.P., and his subordinate contractors presented at the outset what looked like a moderate programme—namely, to proceed immediately with the work and receive later in the neighborhood of $800,000 a year for thirty years, presumably aggregating about $25,000,000. The credit was a long one certainly; and the ability of Egypt to make such a favorable contract, by which she apparently took little risk, and is to pay away each year but a part of the sum the reservoir brings to her exchequer, proves the enviable position of her credit. The transaction may further be taken as an earnest of Great Britain's intention to retain indefinitely her control of the country of the Nile.

In an official report by Earl Cromer, the British Diplomatic Agent in Egypt, it has been stated that the actual cost of the Assouan dam is about $12,500,000, and that it will increase the earning power of Egypt fully $13,000,000 annually—in other words, that it will pay for itself every twelvemonth. The reservoir will permit the additional irrigation of 1,600,000 acres, Lord Cromer writes, and it is estimated that it will bring additional revenue to the Egyptian government, in the shape of taxes, of $1,900,000 per year, and indirectly even more. The cost of the dam was about ten per cent. in excess of the estimate. When the builders went below the river's bed, seeking a solid foundation for the enormous structure, they encountered unsubstantial rock where imperishable granite had been looked for. This made it necessary to dig forty feet deeper in places than had been intended.

The contract was signed just five years ago this month, and the date fixed for the completion of the work was July 1st, 1903; but the low summer levels, especially in 1900, were so favorable that unexpected progress was made by Sir John Aird & Sons, and the dam was completed before the advent of the flood last December, practically a year before the specified contract time.

The dam is straight from end to end, and a mile and a quarter long; its thickness at its deepest part is eighty-two feet, tapering to twenty-three feet at the top, which is finished as a roadway. The height from the lowest part of the foundation to the coping is 131 feet. The maximum "head" of the impounded water will be sixty-five feet, and, when the dam is full, the volume of water is calculated at 234,300,000,000 gallons—practically, a billion tons. In years of ordinary Nile conditions, the storage will be completed in March, and the vitalizing liquid will be liberated during May, June, and July; then, for several months, when the valley of the Nile will continue athirst, the sluices will be kept open to their widest capacity, that the remaining flow of the river may not be checked. The Assouan structure differs in several respects from any great dam hitherto built. In the first place, no dam for impounding water has ever been made on any river approaching the size of the Nile; and, in the second place, it is both dam and waterway, a combination exceedingly difficult to effect. The released water, coming always from the bottom of the reservoir, will carry the enriching "red" precipitation that has been swept by the current all the way from Abyssinia. To confine Father Nile in floodtime would be hopeless, for the flow may amount to 15,000 tons of water a second. The dam has 180 sluice openings, mostly twenty-three feet high by six feet six inches wide. Where the gates are subject to abnormal pressure they are hung on rollers admitting of easy and certain raising. The masonry is of local granite, set in Portland cement mortar, the interior being of rubble, set by hand, with about forty per cent. of the bulk in cement mortar, mixed four parts of sand to one of cement. The surface work of the huge structure is of coursed rock-faced ashlar, but sluice-linings and locks are finely dressed.

During construction, there was great need at times for completing a section before the coming of High Nile, and it is recorded that at one point as much as 3,600 tons of masonry were put in place in a single day. Every facility for expeditious work was utilized, including lines of railway from quarries to the spot where blocks of stone were deposited by steam cranes. Ten thousand natives were employed in certain months, and a thousand or more European stone-cutters, mostly Italians and Greeks, were kept constantly at work.

While formerly navigation at Assouan was feasible only at High Nile, and then with great difficulty, it is now perennial; for on the west flank of the dam a navigation "ladder" of four locks, each 260 feet long by 32 feet wide, is in successful operation. Hitherto, trans-shipment of passengers and goods at the first cataract has been obligatory throughout a greater part of the year. The steamer or dahabieh of the tourist may now proceed, uninterrupted by rock barriers, from Cairo to Wady Halfa.

Subordinate to the great dam, a smaller one, in character like the barrage at the apex of the Delta, has been built at Assiout, 250 miles south of Cairo. Its function is to give sufficient "head" to the river to force the water into the irrigation canals that vein hundreds of thousands of acres north of Assiout. This new aid to agriculture is constructed of stone, whereas the Delta barrage is of brick. Its total length is just over a half-mile—2750 feet; and it has a set of navigation locks, and 111 arched sluices for regulating the flood discharge. Experts estimate that this Assiout barrage, in conjunction with the Ibramieh canal, whose intake is immediately above, will bring 300,000 acres under cultivation, and immeasurably enhance the fertility of the Fayoum province.

I may quote from a description, penned by Sir Benjamin Baker, illustrative of obstacles encountered on the Assiout work:

> "The piers and arches are founded upon a platform of masonry 87 feet wide and 10 feet thick, protected up and down by a continuous and impermeable line of cast iron grooved and tongued sheet piling, with cemented joints. This piling extends into the sand bed of the river to a depth of 23 feet below the upper surface of the floor, and thus cuts off the water and prevents the undermining action which caused so much trouble and expense in the case of the Delta barrage. The height of the roadway above the floor is 41 feet, and the length of the piers up and down stream 51 feet. The river bed is protected against erosion for a width of 67 feet up stream by stone pitching, with clay puddle underneath to check infiltration, and down stream for a similar width by stone pitching, with an inverted filter-bed underneath, so that any springs which may arise from the head of water above the sluices shall not carry sand with them from underneath the pitching. . . .
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> . . . . "It is easy enough to construct dams and barrages on paper; but wherever water is concerned the real difficulty and interest is in the practical execution of the works, for water never sleeps, but day and night is stealthily seeking to defeat your plans."

The Egypt of the map contains more than four hundred thousand square miles, an expanse seven times as great as the New England States collectively; but the practical Egypt—that which produces crops and sustains life—is considerably less than the States of Massachusetts and Connecticut united. This ribbon-like strip of alluvial land bordering the Nile, a very few miles wide on either bank, with the Delta included, measures not more than ten thousand five hundred square miles.

To state with exactitude what will be the expansion realized by the two Nile dams finished last year, is impossible. Not only will the alluvial area be enormously enlarged, but, augmented irrigation provided, the area now under tillage will be rendered more productive. The benefits contemplated are not to be realized at once. But I deem it within the bounds of reason to record the belief that the *effect,* by 1908, of the recent adjuncts to irrigation in the Nile valley will be equal to the addition to the cultivable area which I call "practical Egypt" of fully twenty per cent., extravagant as that estimate may be regarded; in other words, that an area equal to that of Rhode Island will be added to the figurative area of Massachusetts and Connecticut employed in this article for the purpose of ready comprehension.

This will be expansion in its truest sense. As an object lesson, it should have no more interested observers than in the United States, where the irrigation engineer is succeeding the railway builder as a developer of the western and southwestern domain.

The agricultural industry that will be chiefly benefited by the Assouan dam and the tributary barrage at Assiout is cane-culture. The Nile cane is of such exceptional quality that much European capital has of late years been invested in its cultivation, while crushing-factories have gone up on the river's banks as if by magic. A vast amount of French and British capital found investment in sugar enterprises in Upper Egypt during the years when the Cuban crop was curtailed by strife and political uncertainties. The peasant farmer in Upper Egypt has become a capitalist in a small way through the "boom" in cane-raising. Egyptian cane is prized as the peer of all canes in saccharine productivity, and experts have long held that the valley of the Nile presented to an unparalleled degree climatic and economical advantages for sugar-raising.

Aided by nature in producing a staple commodity of superior quality, at a cost somewhat under that of production in most other countries, it is obvious that augmented irrigation facilities mean a rapidly increasing output of raw sugar, and it would not be surprising if the crop were trebled in the coming five years. It is rarely taken into account, when comparing Egyptian sugar with that of Asiatic and Malaysian countries, that the former—shipped always from Alexandria—reaches European ports at about the cost for carriage that sugar from the Far East pays as Suez Canal toll. Sugar has long been Egypt's crop of second importance. Statisticians must hereafter take the Egyptian crop into account when dealing with the world's production.

Since the American Civil War it has been bred in the bone of Englishmen to want to render Lancashire spindles independent of

United States cotton fields. The wish finds frequent expression at meetings of British manufacturers, and the underlying object of the recently incorporated Manchester Society for the Encouragement of Cotton Growing in the Colonies is readily discernible. France, too, has just formed a similar association, "in consequence of the increasing menace of American competition, which, if unchecked, will become a monopoly," its prospectus stated. English and French journals feelingly described the official completion of the Assouan dam as a gigantic step toward freeing Europe from the thraldom of American cotton.

As a fact, cotton culture will receive comparatively little impetus from the augmented irrigation facilities in Egypt, and the area of the crop will probably never extend much beyond the present limits of the Delta. Some immediate increase of territory devoted to the fibre is inevitable, but it is my judgment that a crop of a million 750-pound bales (equal to a million and a half American bales) is the maximum output to be looked for for several years to come.

Every rose has its thorn; and by the time the new Assouan reservoir is full, say in March or April, I predict that we shall hear much, through the English and Continental press, of the desecration of Philæ, for the flooding of the island—a half-mile south of the dam—seems inevitable. Hundreds of tourists are certain to be shocked when they discover the island awash, its structures rising without meaning from a mirroring lake; and they will pour out their angry indignation forthwith through "letters" to favorite newspapers at home. Thus, Philæ is certain to be a world-topic this spring.

Reluctance or fear of injuring the architectural treasures of Philæ compelled the British administration of Egypt to hesitate for years about damming the Nile at the first cataract, and I always believed that the real purpose of the international commission to consider Nile sites was to obtain outside certification that the Assouan location was pre-eminent, and that the æsthetic must yield to the utilitarian. Probably no English engineer ever seriously thought of building a dam at any other point. When the subject was mooted eight years ago, and the fact published that Philæ was threatened, meetings were held by learned societies everywhere to protest against possible desecration, and memorials poured in upon the Egyptian government from antiquarians, Egyptologists, archæologists, and literary people, praying that Philæ should be undisturbed. The late Sir Frederick Leighton, President of the Royal Academy, did not hesitate to say that "any tampering with Philæ would be a lasting blot on the British occupation of Egypt." A torrent of newspaper invective was hurled at Britain's rule of the Nile, in which the word "vandalism" was frequently used.

"Why threaten to destroy one of the world's most priceless gems, in order that European holders of Egyptian bonds might be more certain of their interest?" was the universal inquiry. "What is a useless temple," retorted the engineers, "in comparison with a work involving the welfare of millions of human beings?"

To pacify public opinion, a modified scheme was prepared, calling for the present dam, two-thirds as high as first proposed, but which, its authors confessed, would cause the foundations of "Pharaoh's Bed" and the pylons and pavilion to be submerged for a few months in the year. It is open to suspicion that the zealous engineers understated the extent of the submergence; and it would not be surprising if the dam were found to be a trifle higher than the elevation that was going to establish a mean between the æsthetic and utilitarian.

Read between the lines, this quotation from a document published by the chief engineer of the Assouan enterprise should be sufficient to prepare the world for disquieting news from Philæ:

> "When the reservoir is full, the island of Philæ will in places be slightly flooded. As the temples are founded partly on loose silt and sand, the saturation of the hitherto dry soil would cause settlements, and no doubt injury to the ruins. To obviate this risk, all the important parts, including the well-known Kiosk or 'Pharaoh's Bed,' have been either carried on steel girders or underpinned down to rock, or, failing that, to the present saturation level. It need hardly be said that, having regard to the shattered condition of the columns and entablatures, the friability of the stone, and the running sand foundation, the process of underpinning was an exceptionally difficult and dangerous task."

FREDERIC COURTLAND PENFIELD.